Journal of Education and Practice www.iiste.org
ISSN 2222-1735 (Paper) ISSN 2222-288X (Online)
Vol.6, No.20, 2015

Bridging Gender Gap in the Physics Classroom: The Instructional Method Perspective

Dr. (Mrs) Obafemi, Deborah.T.A.
Department of Currriculum Studies and Educational Technology, University of Port Harcourt, P M B 5323, Port Harcourt. Rivers State, Nigeria.

Abstract
The study investigated the influence of students' gender on their understanding, application and analysis of Light waves concept in physics in Ikwerre Local Government Area of Rivers State, Nigeria. A quasi-experimental pretest posttest design comprising of three experimental and one control group was used, each group was taught with a different Instructional method. A purposively selected sample of fifty- five (55) physics students of Senior Secondary 2 (SS2) class was involved in the study. Two instruments- Mathematics Ability Test (MAT) and Physics Performance Test on Light Waves (PPTLW) with reliability coefficients of 0.97 and 0.89 respectively were used. The performances of the students were considered at the levels of understanding, application and analysis of Light waves. Data collected was analysed using Mean scores and Percentages for the research questions, while 4x2 Multivariate Analysis of Covariance was used to test the hypotheses. Analysis of results showed that Demonstration method stands out as an effective method in bridging gender gap in the learning of difficult physics concepts like Light waves. Furthermore, a significant difference was found between the performance of male and female students in the application of Light waves while there was no significant difference between the performance of male and female students in the understanding and analysis of Light waves.The Post hoc analysis indicates that male students taught using Guided-discovery method contributed more to the significant difference between the performance of male and female students in the application of Light waves.
Keywords: Physics, Gender, Light Waves, Instructional methods, Demonstration Method, Guided-discovery method.

1. Introduction

The start of the new Millennium witnessed an agreement between world leaders under the auspices of United Nations to pursue a program aimed at developing their nations. Items 1 and 3 of the components of the program termed 'Millennium Development Goals' are to eradicate extreme poverty and hunger, and to promote gender equality and empower women. Little wonder then, that Institute of Physics (2006) sees bridging the gender gap in physics as one important goal in the development of physics education at the global level. This is premised on the fact that, the concepts, principles and practice of Physics contributes so much to national development, technology and many fields of human endeavour. This ranges from household and domestic life in which female students are so involved, to professions like engineering, medicine, telecommunication, manufacturing and agriculture, which has also attracted active participation of the female students especially in recent time.

Physics, a science subject that is concerned with matter and its relation with energy, is taught at the Senior Secondary level in Nigerian secondary schools having the following objectives:
- provide basic literacy in physics for functional living in the society;
- acquire basic concepts and principles of physics as a preparation for further studies;
- acquire essential scientific skills and attitudes as a preparation for technological application of physics; and
- stimulate and enhance creativity NERDC (2009).

Despite the efforts aimed at improving Science, Technology and Mathematics (STM) education in Nigeria, the benefits have not been the same for males and females. Girls are underachieving and under-represented in physics (Ogunleye, 2001). Gonzuk & Chagok (2001) found that girls are easily discouraged towards taking physics because of the negative impression that physics is just difficult. Nkwo, Akinbobola & Edinyang (2008) discovered that male students achieved higher than girls. Ukwungu (2006) after performing a meta-analysis of gender differences in students' performance in physics discovered higher success rate in boys than girls. Okwo & Otubah (2007) also reported that boys do better than girls in physics essay test. On the other hand, Adeoye (2010) reported that females achieved better than males when the physics test items are based on physics concepts that require learners of low numerical ability while the reverse is the case when the test is based on physics concepts that require learners of higher numerical ability. This gender difference in achievement in Nigeria students have been linked to many factors-like the way science is being taught in Nigerian secondary schools, socio-cultural factors, perceived difficult and abstract nature physics, fear of failure, the mathematical nature of physics, among others. (Okebukola, 1996; Ogunneye & Lasisi, 2008).The under representation and poor performance of girls in physics prevents the empowering of women and limits the full participation of women in national development. It also limits their potentials for full human capital development to the optimum level.

However, according to Nsofor (2001), Akinbobola (2005) and Onwioduokit, Akinbobola, & Udoh (2008), boys and girls could equally perform well if exposed to the same conditions of learning. In the same vein, the results of the studies conducted by Iorchugh (2006) and Wambugu & Changeiywo (2008) show that gender had no significant influence on students' achievement. Ogunneye & Lasisi (2008) noted that the development of any nation requires that all students (male and female) be adequately empowered to be able to contribute their quota meaningfully and appropriately. In the view of Adegoke (2009), an equal number of women and men in science and technology related occupations would promote a more equal society. Ogunneye & Lasisi (2008) thus concluded that the teaching of physics must be given a special attention to make both boys and girls desire not to only want to study physics, but also desire to make a success of its study, so that thereafter they may go for careers in physics.

An analysis of the performance of students in WASSCE physics in the years 1999-2011 shows that the number of female students who enrolled for physics is less than 50% of the total enrolment figure. So also is the number of female students who had credits and above, less than 50% of the total number of students who had credits and above. This implies that there is still gender gap in the enrolment and performance of students in physics. What could be the cause of this gender gap in physics?. What could be the cause of the poor performance of female students in physics? Could it be due to the instructional method used in teaching physics concepts?. This study thus intends to investigate the influence of gender on the performance of students in the study of Light Waves concept in physics.

2. Purpose of the Study

The purpose of this study is to investigate the influence of gender on the performance of students in the study of Light Waves concept in physics. The specific objectives of the study were to:

(i) Determine the influence of students' gender on their understanding, application and analysis of Light waves.

(ii) Assertain the influence of students' gender on their understanding, application and analysis of Light waves, considering the instructional method.

3. Research Questions

(i) What is the influence of students' gender on their understanding, application and analysis of Light waves?

(ii) What is the influence of students' gender on their understanding, application and analysis of Light waves, considering the instructional method?.

4. Research Hypotheses

The null hypotheses tested in this study were:

(i) There is no significant difference between the performances of male and female students with respect to understanding, application and analysis of Light waves.

(ii) There is no significant difference between the performances of male and female students with respect to understanding, application and analysis of Light waves considering the instructional method.

5. Research Method

The study had a quasi-experimental pretest posttest design comprising of three experimental and one control group. A purposively selected sample of fifty- five (55) physics students of Senior Secondary 2 (SS2) class in Ikwerre Local Government Area of Rivers State, Nigeria was involved in the study. Two instruments- Mathematics Ability Test (MAT) and Physics Performance Test on Light Waves (PPTLW) with reliability coefficients of 0.97 and 0.89 respectively were used. The two instruments were administered to the students as pretest after which the students in each of three experimental and one control group were taught Light waves using one of four Instructional methods (Collaborative, Demonstration (teacher-student demonstration), Guided-discovery and Lecture method) for three weeks. Thereafter, Physics Performance Test on Light Waves (PPTLW) was administered to the students as post test and their performances were considered at the levels of understanding, application and analysis of Light waves. The data generated from their responses was analysed using Mean scores and Percentages for the research questions, while 4x2 Multivariate Analysis of Covariance was used to test the hypotheses.

6. Results and Discussion of Findings

Research Question 1**.** What is the influence of students' gender on their understanding, application and analysis of Light waves?

Table 1 shows that in the understanding of Light waves, male students had a mean gain percent of 55.6%, while the female students had a mean gain percent of 40.6%. In the application of Light waves, male students had a mean gain percent of 34.5%, while the female students had a mean gain percent of 20.7%. In the analysis of Light waves, male students had a mean gain percent of 50.0%, while the female students had a mean gain percent of 20.0%. Summarily, the table revealed that in Light waves, male students performed better than the female students at the level of understanding, application and analysis. Furthermore, the students gained most at the level of understanding of Light waves irrespective of their gender. However, the performance of the students irrespcetive of their gender is not too good (the highest mean gain percent for the male students being 55.6% and 40.6% for the female students).

Research Question 2. What is the influence of students' gender on their understanding, application and analysis of Light waves, considering the instructional method?.

Table 2 shows that at the level of understanding of Light waves, male students had their highest mean gain percent 100.0% in Guided – discovery method while the female students had their highest mean gain percent of 117.6% in Demonstration method. At the level of application of Light waves, male students had their highest mean gain percent of 55.6% in Demonstration method while the female students also had their highest mean gain percent of 76.5% in Demonstration method. At the level of analysis of Light waves, male students had their highest mean gain percent 90.0% in Collaborative method while the female students had their highest mean gain percent of 130.0% in Demonstration method.

7. Research Hypotheses

Hypotheses 1(Ho_1): There is no significant difference between the performances of male and female students with respect to understanding, application and analysis of Light waves.

Table 3 presents the summary of 4x2 Analysis of Covariance of students' understanding of Light waves classified by instructional methods and gender, using pretest scores as a covariate. The result of the hypotheses shows that Gender is not significant since its calculated $F_{1,46}$ value is 0.894 at degree of freedom of 1,46 and probability level of 0.05 against the $F_{1,46}$ critical value of 4.00. This implies that there is no significant difference between the performances of male and female students with respect to understanding of Light waves.

Table 4 presents the summary of 4x2 Analysis of Covariance of students' application of Light waves classified by instructional methods and gender, using pretest scores as a covariate. The result of the hypotheses shows that Gender is significant since its calculated $F_{1,46}$ value is 4.052 at degree of freedom of 1,46 and probability level of 0.05 against the $F_{1,46}$ critical value of 4.00. This implies that there is significant difference between the performances of male and female students with respect to application of Light waves.

Table 5 shows the summary of results of the Post hoc analysis of students' application of Light waves based on the four instructional methods which indicates that method 3 which is the Guided – discovery method contributed most to the significant difference between the effects of the instructional methods.
The Post hoc analysis on **Table 6** on the other hand indicates that the male students contributed more to the significant difference between the influence of gender. The study also revealed that the Post hoc analysis on **Table 7** indicates that male students taught using Guided-discovery method contributed more to the significant difference between the performance of male and female students when the instructional methods are considered.

Furthermore, a 4x2 Analysis of Covariance of students' analysis of Light waves classified by instructional methods and gender, using pretest scores as a covariate was carried out as presented in **Table 8.** The result shows that Gender is not significant since its calculated $F_{1,46}$ value is 0.526 at degree of freedom of 1,46 and probability level of 0.05 against the $F_{1,46}$ critical value of 4.00. We therefore conclude that there is no significant difference between the performance of male and female students with respect to analysis of Light waves.

Hypotheses 2 (Ho_2): There is no significant difference between the performances of male and female students with respect to understanding, application and analysis of Light waves, considering the instructional method.

Table 3 shows that the interaction of Method and Gender is not significant since its calculated $F_{3,46}$ value is 0.521 at degree of freedom of 3,46 and probability level of 0.05 against the $F_{3,46}$ critical value of 2.76. This shows that there is no significant difference between the performances of male and female students with respect to understanding of Light waves when the instructional methods are considered.

Table 4 shows that the interaction of Method and Gender is significant since its calculated $F_{3,46}$ value is 3.488 at degree of freedom of 3,46 and probability level of 0.05 against the $F_{3,46}$ critical value of 2.76. This shows that there is significant difference between the performances of male and female students with respect to application of Light waves, considering the instructional method. The Posthoc analysis on **Table 7** indicates that male students taught using Guided-discovery method contributed more to the significant difference between the performance of male and female students when the instructional methods are considered.

Table 8 shows that the interaction of Method and Gender is not significant since its calculated $F_{3,46}$ value is 0.793 at degree of freedom of 3,46 and probability level of 0.05 against the $F_{3,46}$ critical value of 2.76. This shows that there is no significant difference between the performances of male and female students with respect to analysis of Light waves when the instructional methods are considered.

8. Discussion of Findings

The result earlier presented in **Table 1** on the influence of students' gender on their understanding, application and analysis of Light waves evidently revealed that the female students are still lagging behind their male counterparts in physics. This finding is in consonance with the findings of Ogunleye (1999), Ukwungu (2006), Okwo & Otubah (2007) and Nkwo, Akinbobola & Edinyang (2008). On the average, the students' performance was not encouraging. This may be because the students found Light waves concept difficult to learn. The concept of Light waves was actually found to be one of the concepts identified to be a difficult concept by Teachers and students in past studies by Onwioduokit (1996), Njoku (2005), Fisher (2009) and Obafemi (2013).

Again, the students' performance show that the students did not do well at higher levels of the Taxonomy of Educational objectives. This means that by implication, they are still operating more at a low level of Understanding. This may be one of the reasons for the poor students' performance that is still being recorded in physics examinations. The study has further shown that, whereas at the level of understanding of Light waves, male students gained most in Guided-discovery method, but / while the female students gained most in Demonstration method. At the level of the application of Light waves, all the students irrespective of their gender gained most in Demonstration method. At the level of the analysis of Light waves, male students gained most in Collaborative Learning method, while the female students gained most in Demonstration method. As the level rises on the Taxonomy of Educatioal objectives, the students gained more in instructional methods that are less tasking on the part of the students. This suggests that each level on the Educational objective may requirre different appropriate instructional method in other to enhance the students' performance.

Summarily, the table 1 shows that in Light waves, male students gained most in Guided – discovery method, while the female students gained most in Demonstration method. Demonstration method therefore stands out as an effective method in bridging gender gap in the learning of Light waves. This is in agreement with Sprott (1996) who reported that the teaching of physics is clearly enhanced by the use of demonstration. This is also in consonance with Sharp (2004) who found that undertaking practical activities that involved problem-solving would enhance learning in science. The finding is also in consonance with Chang, Jones, & Kunnemeyer (2002) who found that students, who were taught physics with the interactive teaching approach promoted their learning interest, introduced them to real life experiences, stimulated their thinking about physics concepts and enhanced their conceptual understanding unlike the students taught with the traditional teaching method. It is also in consonace with Obafemi (2013b) who discovered that demonstration method greatly enhanced the performance of students with Low mathematics ability in the analysis of Sound waves.

Comparing Tables 1 and 2, the female students recorded poor mean gain percentages of 40.6%, 20.7% and 20.0% on Table 1 while on Table 2, they recorded mean gain percentages as high as 117.6%, 76.5% and 130.0% all in Demonstration method as against 100%, 55.6% and 90.0% obtained by their male counterparts. This result further shows that female students had percentage mean gains which were higher than the ones for the male students at the three levels of understanding, application and analysis, though in different instuctional methods. This reveals that female students can favourably compete with their male counterparts if the appropriate instructional method is used in teaching them. This finding agrees with the submission of Akinbobola (2005) and Onwioduokit, Akinbobola & Udoh (2008) that male and female students could equally perform well if exposed to the same conditions of learning.

From the Hypotheses, it is shown that there is no significant difference between the performances of male and female students with respect to understanding and analysis of Light waves. This finding agrees with the results of the studies conducted by Iorchugh (2006) and Wambugu & Changeiywo (2008) which show that gender had no significant influence on students' achievement. However, there is significant difference between the performances of male and female students with respect to application of Light waves.

Furthermore, the study has shown that there is no significant difference between the performances of male and female students with respect to understanding and analysis of Light waves when the instructional methods are considered. However, there is significant difference between the performances of male and female students with respect to application of Light waves when the instructional methods are considered.

9. Implications of Findings

This finding implies that female students will not be able to favourably compete with their male counterparts in their performance in physics if the appropriate instructional method is not used in teaching Light waves and other physics concepts. It has shown that the efforts and desire to bridge the noticeable gender gap which has continued to persist points to the need to revisit the instructional methods of teaching senior secondary school physics. This is because the use of appropriate instructional methods will bring out the strength in female students. Furthermore, Physics students may not be able to operate at higher levels of Educational objectives other than Understanding level if the appropriate instructional methods are not used by the teachers.

10. Conclusion

Demonstration method (Teacher-student demonstration) stands out as an effective method in bridging gender gap in the learning of Light waves and other difficult physics concepts. Also, consideration of the different levels of Educaional objectives during instruction and assessment will expose the areas of weakness and strength of the students. In view of the laudable objectives of Physics education in Nigerian Secondary Schools and the Milleniun Development Goals, it is expedient that every student (whether male or female) be given the opportunity to be well grounded in the principles, concepts and skills offered in the study of physics in other to achieve these goals and objectives.

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Table 1: Gain scores of the understanding, application and analysis of Light waves by male and female students.

	Understanding				Application				Analysis			
G	Pre test $\bar{X}$	Post test $\bar{X}$	Mean Gain	Mean Gain %	Pre test $\bar{X}$	Post test $\bar{X}$	Mean Gain	Mean Gain %	Pre test $\bar{X}$	Post test $\bar{X}$	Mean Gain	Mean Gain%
M	3.6	5.6	2.0	55.6	2.9	3.9	1.0	34.5	2.2	3.3	1.1	50.0
F	3.2	4.5	1.3	40.6	2.9	3.5	0.6	20.7	2.5	3.0	0.5	20.0

KEY: CLM- Collaborative Method, DM- Demonstration Method,
GDM- Guided-discovery Method, LM- Lecture Method.
G- Gender, M- Male, F- Female.

Table 2: Gain scores of students' understanding, application and analysis of Light waves by gender and instructional method.

G	Inst. Meth.	Understanding Pre test $\bar{X}$	Post test $\bar{X}$	Mean Gain	Mean Gain %	Application Pre test $\bar{X}$	Post test $\bar{X}$	Mean Gain	Mean Gain%	Analysis Pre test $\bar{X}$	Post test $\bar{X}$	Mean Gain	Mean Gain %
	CLM	4.0	5.8	1.8	45.0	2.4	3.4	1.0	41.7	2.0	3.8	1.8	90.0
	DM	3.2	4.6	1.4	43.8	2.7	4.2	1.5	55.6	1.8	3.1	1.3	72.2
M	GDM	3.0	6.0	3.0	100.0	4.3	5.0	0.7	16.3	2.7	3.3	0.6	22.2
	LM	4.1	6.0	1.9	46.3	2.3	3.0	0.7	30.4	2.3	2.8	0.5	21.7
	CLM	2.5	5.3	2.8	112.0	4.3	3.6	-0.7	-16.3	3.8	3.5	-0.3	-7.9
	DM	1.7	3.7	2.0	117.6	1.7	3.0	1.3	76.5	1.0	2.3	1.3	130.0
F	GDM	3.7	4.3	0.6	16.2	2.8	3.7	0.9	32.1	2.5	3.8	1.3	52.0
	LM	5.0	4.5	-0.5	-10.0	2.6	3.8	1.2	46.2	2.5	2.3	-0.2	-8.7

KEY: CLM - Collaborative Method, DM - Demonstration Method,
GDM- Guided-discovery Method, LM - Lecture Method.
G- Gender, M - Male, F- Female.

Table 3: Summary of 4x2 Analysis of Covariance of students' understanding of Light waves classified by instructional methods and gender, using pretest scores as a covariate.

Dependent Variable: Post test scores on understanding

Source of variation	Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	52.975[a]	8	6.622	1.564	ns
Intercept	221.652	1	221.652	52.349	s
Pretest	13.355	1	13.355	3.154	ns
Main Effect					
Method	13.562	3	4.521	1.068	ns
Gender	3.785	1	3.785	0.894	ns
Interactions					
First order					
Method * Gender	6.615	3	2.205	0.521	ns
Error	194.770	46	4.234		
Total	1906.000	55			
Corrected Total	247.745	54			

a. R Squared = 0.214 (Adjusted R Squared = 0.077)

Table 4: Summary of 4x2 Analysis of Covariance of students' application of Light waves classified by instructional methods and gender, using pretest scores as a covariate.

Dependent Variable: Post test scores on application

Source of variation	Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	36.105[a]	8	4.513	4.368	s
Intercept	42.561	1	42.561	41.190	s
Pretest	15.832	1	15.832	15.322	s
Main Effect					
Method	9.830	3	3.277	3.171	s
Gender	4.187	1	4.187	4.052	s
Interactions					
First order					
Method * Gender	10.813	3	3.604	3.488	s
Error	47.532	46	1.033		
Total	775.000	55			
Corrected Total	83.636	54			

a. R Squared = 0.432 (Adjusted R Squared = 0.333)

Table 5: Post hoc analysis of students' application of Light waves based on the four instructional methods.

Pairwise Comparisons

Dependent Variable: Post test scores on application

(I) Method	(J) Method	Mean Difference (I-J)	Std. Error	Sig.[a]	95% Confidence Interval for Difference[a] Lower Bound	Upper Bound
1.00	2.00	-1.179*	0.478	0.017	-2.141	-0.217
	3.00	-1.276*	0.476	0.010	-2.235	-0.317
	4.00	-0.854*	0.393	0.035	-1.644	-0.063
2.00	1.00	1.179*	0.478	0.017	0.217	2.141
	3.00	-0.098	0.519	0.852	-1.142	0.947
	4.00	0.325	0.404	0.425	-0.488	1.138
3.00	1.00	1.276*	0.476	0.010	0.317	2.235
	2.00	0.098	0.519	0.852	-0.947	1.142
	4.00	0.423	0.440	0.342	-0.463	1.308
4.00	1.00	0.854*	0.393	0.035	0.063	1.644
	2.00	-0.325	0.404	0.425	-1.138	0.488
	3.00	-0.423	0.440	0.342	-1.308	0.463

Based on estimated marginal means

*. The mean difference is significant at the 0.05 level.

a. Adjustment for multiple comparisons: Least Significant Difference (equivalent to no adjustments).

Journal of Education and Practice
ISSN 2222-1735 (Paper) ISSN 2222-288X (Online)
Vol.6, No.20, 2015

Table 6: Post hoc analysis of students' application of Light waves based on gender.

Pairwise Comparisons

Dependent Variable: Post test scores on application

(I) Gender	(J) Gender	Mean Difference (I-J)	Std. Error	Sig.[a]	95% Confidence Interval for Difference[a] Lower Bound	Upper Bound
1.00	2.00	0.627*	0.312	0.050	5.564E-5	1.255
2.00	1.00	-0.627*	0.312	0.050	-1.255	-5.564E-5

Based on estimated marginal means

*. The mean difference is significant at the 0.05 level.

a. Adjustment for multiple comparisons: Least Significant Difference (equivalent to no adjustments).

Table 7: Post hoc analysis of students' application of Light waves based on the interaction of the instructional methods and gender.

Method * Gender

Dependent Variable: Post test scores on application

Method	Gender	Mean	Std. Error	95% Confidence Interval Lower Bound	Upper Bound
1.00	1.00	3.514[a]	0.361	2.787	4.241
	2.00	1.813[a]	0.538	0.730	2.895
2.00	1.00	4.233[a]	0.339	3.551	4.915
	2.00	3.452[a]	0.598	2.248	4.656
3.00	1.00	4.276[a]	0.615	3.037	5.514
	2.00	3.604[a]	0.415	2.768	4.440
4.00	1.00	3.194[a]	0.298	2.595	3.793
	2.00	3.840[a]	0.322	3.193	4.487

a. Covariates appearing in the model are evaluated at the following values: Pretest = 2.6909.

Table 8: Summary of 4x2 Analysis of Covariance of students' analysis of Light waves classified by instructional methods and gender, using pretest scores as a covariate.

Dependent Variable: Post test scores on analysis

Source of variation	Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	34.350[a]	8	4.294	3.004	s
Intercept	47.219	1	47.219	33.031	s
Pretest	22.146	1	22.146	15.492	s
Main Effect					
Method	5.433	3	1.811	1.267	ns
Gender	0.751	1	0.751	0.526	ns
Interactions					
First order					
Method * Gender	3.399	3	1.133	0.793	ns
Error	65.759	46	1.430		
Total	638.000	55			
Corrected Total	100.109	54			

a. R Squared = 0.343 (Adjusted R Squared = 0.229)